Intercept Technology – a Breakthrough in Shelf-Life Extension

10th Annual DoD Government/Industry

Shelf Life Symposium

San Diego
October 23, 2003

Intercept Technology™

Bell Labs developed Intercept Technology to provide:

- **Elimination of corrosive gases that shorten whole-life**
- **Long-term corrosion protection**
- **Permanent ESD electronics protection**
- **Ultra-clean “clean room” packaging**
  - **No or limited outgassing, Non-Volatile Reside (NVR), low ionic contamination**
- **Passive biological inhibition (anti-mold/mildew)**
- **Safe to handle/use packaging**
- **Safe for all equipment**
- **Recyclable (colored PE), environmentally friendly**
- **Does <u>not</u> contain VCIs**

Intercept Technology™

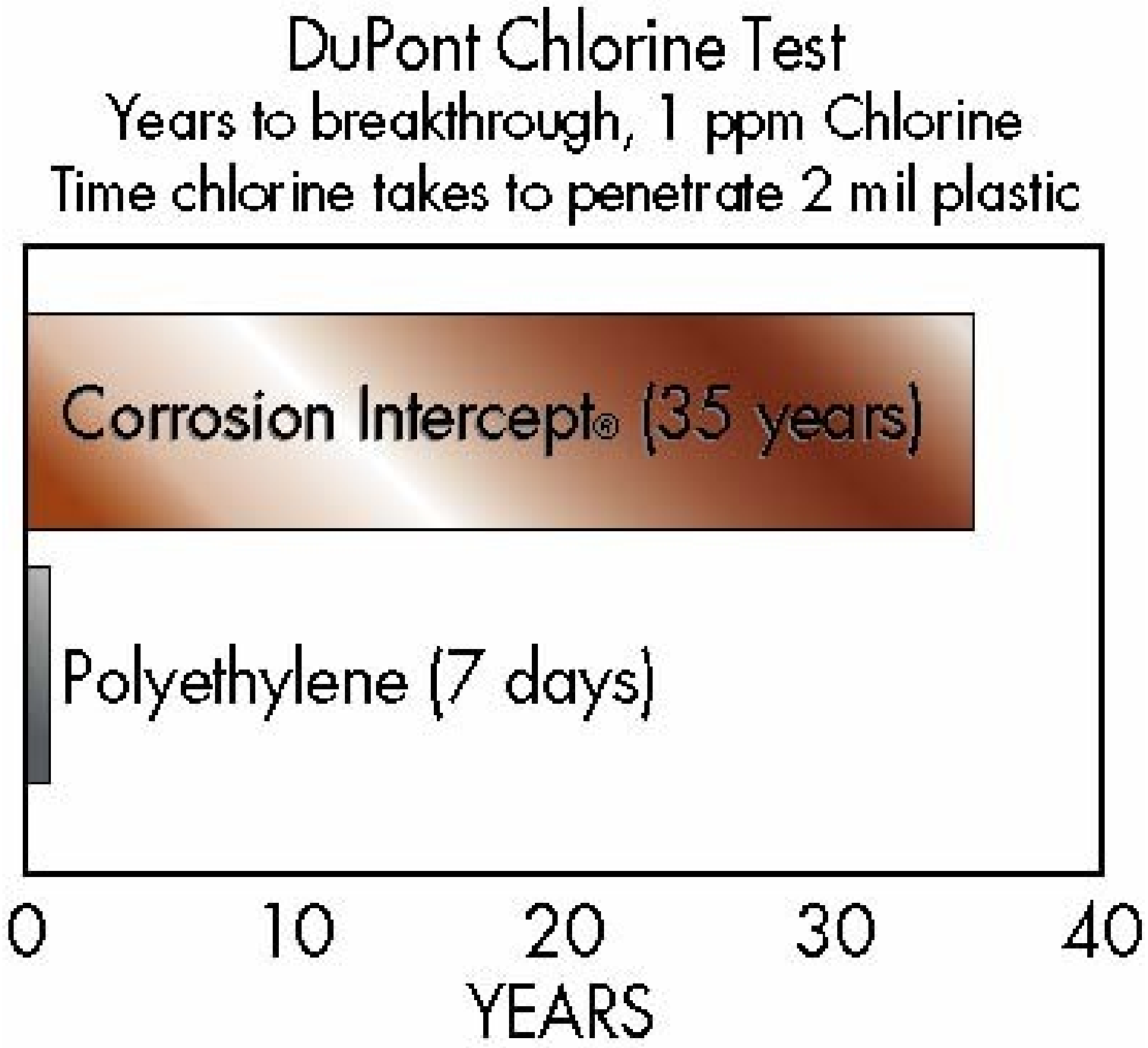
- Intercept is manufactured by reacting highly reactive, high surface area Copper into a polymer matrix. This resin:
  - **Scavenges** trapped corrosive gases by being the preferred corrosion site
  - Provides a very long-term corrosive **gas barrier**
  - Provides **galvanic corrosion protection**
  - **Inhibits mold/mildew** formation on inside surface
- **Advantages:**
  - Effective corrosion protection for **ferrous and non-ferrous metals**
  - **Non-contaminating** and **Non-coating**
  - **Safe** for personnel, equipment, environment
  - A **micro-environment** is formed within a closed Intercept container, one that becomes **free of reactive atmospheric pollution**
- **Disadvantages:**
  - Most forms are opaque

Intercept Technology Electrical Static Discharge (ESD) Properties

- **Permanently Static Dissipative -** 10e6 to 10e8 Ohms/Sq
- **Humidity / Temperature / Moisture Independent**
- **Contains no volatile additives** - no or low outgassing (Meets NASA and Raytheon outgassing specifications)
- **Tribo Charging < 20 volts**
- **Clean room compatible** - no sloughing
- **CDM (charged device) Safe**

Electronics Corrosion Damage Prevention:

- Latent Defects
- Soldering Problems
- Low Yield
- Increased Resistance
- Reduction in Performance
- Poor Connections
- Physical Discoloration, Staining
- Contamination


DuPont Chlorine Test
Years to breakthrough, 1 ppm Chlorine
Time chlorine takes to penetrate 2 mil plastic
Corrosion Intercept® (35 years)
Polyethylene (7 days)
0
10
20
30
40
YEARS

Corrosion as a Shelf Life Issue

- Corrosion can be a **chemical reaction** between a metal and a reactive, or unstable gas or liquid
- Corrosion can be an **electrical reaction** between dissimilar metals
- Corrosion can be an **electro-chemical reaction** between dust and a metal surface
- Corrosion can be caused by **biological action**, such as by sulfur-compound producing molds and bacteria
- The discussion can also be expanded into **surface changes** to non-metallic materials as well – such as wood, cloth, plastics, paper, rubber, elastomeric compounds, etc. all of which are affected adversely by atmospheric pollution

How Does Intercept Work?

- Water and Corrosive Gases
  - Corrosion is caused by the reaction of corrosive gases and the metal surface
  - Water accelerates process & water drops (condensate) can stain surface
  - Ozone acts as an accelerant

S/L of Common Elastomers

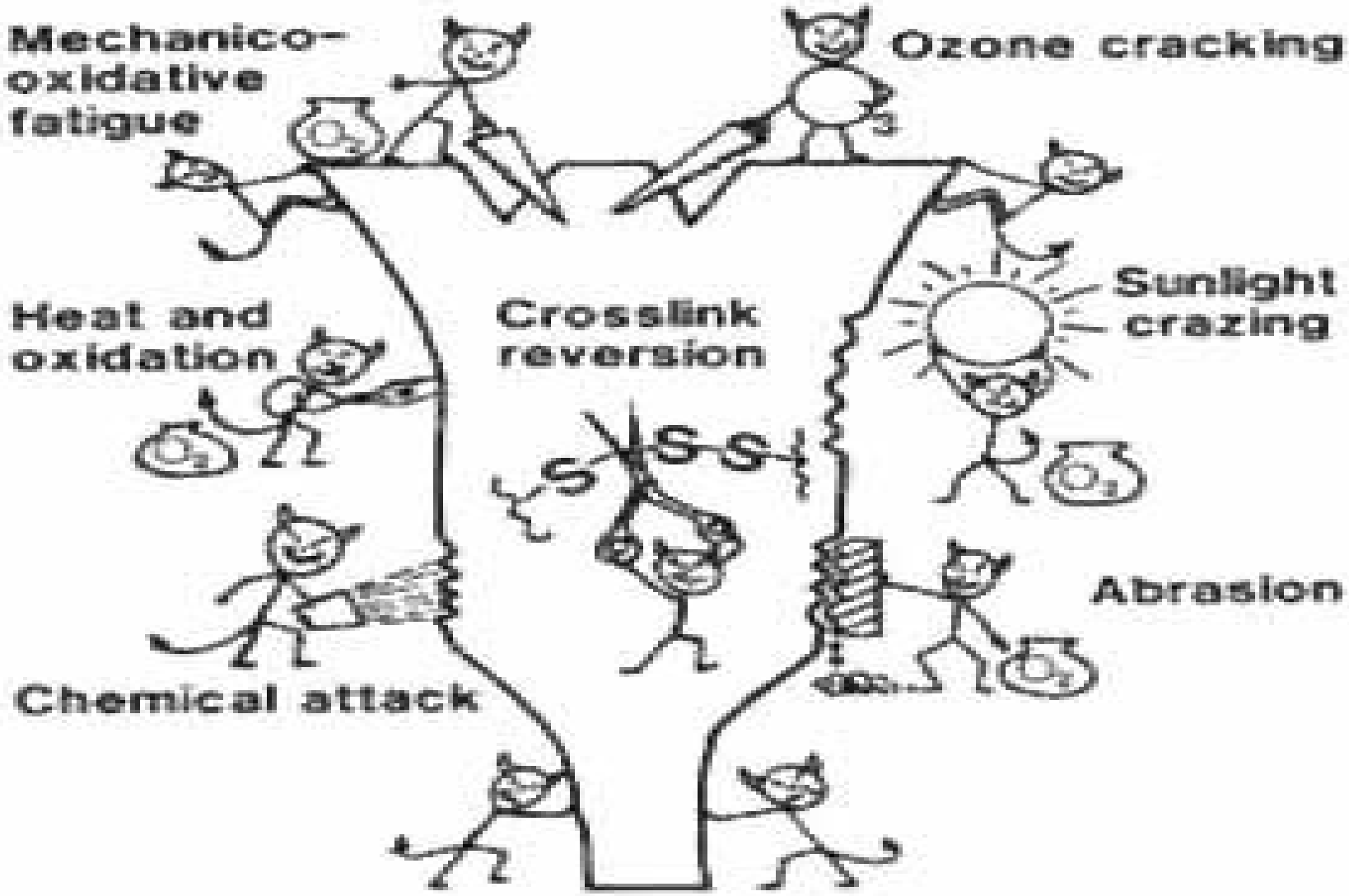
- Nitrile, Polybutadiene, Styrene Butadiene Rubber, Polyisoprene
- Hypalon, Ethylene Propylene, Neoprene, Polyurethane, Epichlorohydrin
- Fluorocarbon, Perfluoroelastomers, Silicone, Fluorosilicone, Polyacrylate, Polysulfide

- **3-5 years**
- **5-10 years**
- **10-20 years**

Factors in Shelf Life Aging

- Oxygen (O_2)
- Corrosive Gases (Atmospheric Pollution)
- Light
- Heat
- Humidity
- Oils
- Solvents
- **Biologicals**
- Particulates

Types of degration in natural and synthetic rubber vulcanizates



Atmospheric Pollution

- Ozone (**O_3**) - reactive oxygen
  - Accelerates degradation of materials in conjunction with other reactive gases / also affects rubber, paper and plastic
- Hydrogen Sulfide (**H_2S**) and Sulfur Dioxide (**SO_2**)
  - Effluent from pulp mills, oil refineries, heavy industry, fossil fuel combustion and decaying vegetation, breakdown of vulcanized rubber, breakdown of paper
- Carbonyl Sulfide (**COS**)
  - From fossil fuel combustion, wood fires and ocean surfaces
- Nitrous Compounds (**NO_x**)

Ozone (O_3)

- Very reactive with many organics
- Ozone-generating equipment such as electric motors, mercury vapor lamps, and high voltage electrical equipment
- Combine with other corrosive gases and moisture to increase deteriorative effects
- Most susceptible are elastomerics, textile fibers and dyes, some paints
- Causes chain-scissioning or cross-linking

Sulfur dioxide (SO_2)

- Absorbs in moisture on surfaces/atmosphere and oxidized to sulfates
- Sulfur consuming bacteria, thiobacillus thioparus being one example, converts atmospheric SO_2 to sulfuric acid, which it uses as a digestive fluid.
- SO_2 and particles of charcoal (soot) produced corrosion much more rapidly than SO_2 and moisture alone because carbon adsorbs SO_2 and creates SO_2 concentration
- SO2 converts to sulfates in atmosphere and on surfaces forming particulates, which can mechanically damage fabrics

Nitrous Oxides (NO_x)

- Damaging to fabric
- Warehouse operations with unvented heaters and combustion powered forklifts have increased NO_x levels
- Promotes fading of fabrics: NO_x has varying rates of absorption to modern fabrics.
- Promotes acid hydrolysis
- In metals causes pitting, selective leaching, and stress corrosion

Fungal Attack Can be as Detrimental as Corrosion

- WWII experience demonstrated extent of fungal problem. Fungus occurs best in warm, humid environments but also is found in cold or dry conditions.
- Fungus can be found on items that may not support fungus but provides surface area support
- Increasing use of organic, non-metallic materials in electrical and electronic assemblies raises fungal risk
- Even the use of materials that do not support fungal growth may not solve the problem because fungi can exist on a given material without feeding on it, creating an undesirable film deposit on the material.
    - Rebecca Sparling, Corrosion Prevention Should Begin on the Drawing Board, Materials Protection, December 1963, pp 8-15

Materials and What Damages Them

1. Paint	1. Surface erosion/discolor by Sulfur oxides, hydrogen sulfide, ozone
2. Textiles	2. Reduced tensile strength by sulfur oxides, nitrogen oxides
3. Textile dyes	3. Fading, color change by nitrogen oxides, ozone
4. Paper	4. Embrittlement by sulfur oxides
5. Elastomerics	5. Cracking by ozone
6. Leather	6. Weakening powdered surface by sulfur oxides
7. Ceramics	7. Changing surface appearance by acid gases, HF
8. Plastics	8. Strength loss

Textiles

- Test: 21% vs 13% strength loss of cotton and rayon when exposed to 0.1 ppm SO_2 in addition to UV & water vapor
- Test: At 0.2 ppm SO_2, nylon strength loss was 80% vs 40% for clean air. Both exposed to UV.
- NO_2, SO_2, ozone, sunlight, water vapor are important factors to fabric deterioration.
- Large particles, which can include SO_2 accumulations, can cut fabric fibers.
- Study: Polyester-cotton/permanent press fabrics stored in warehouses were fading though the fabrics and dyes were thought to be fade resistant. Ozone and humidity combined to fade dye which had not truly absorbed into the fabric. Temperate was less of a factor. One test showed 20% strength decrease with wet ozone vs dry ozone.

Textile Dyes

- Study: some textile dye fade because the dyes had migrated into the permanent press materials but not into the fibers.
- Humidity is an important factor in fading
- Study: Higher concentrations of ozone cause fading. Humidity also was a factor but temperature was a lesser cause.

Elastomeric Attack

Different rates and different ways

- Swelling of polymer that returns to its original condition if the chemical is removed.
  - compounding ingredients contained within may be changed, contaminated, or removed
- Polymer molecules are Irreversibly changed by crosslinking, oxidation, substitution reactions or chain scission.
  - Cracking of rubber and many synthetic elastomers occurs at the double bond.
  - Anti-ozonates added to reduce problem

Coatings

- **Paint consists of pigment and vehicle. Pigment protects the surface, vehicle forms the bonding. Air pollution limits this bonding. SO_2 interferes with drying and accelerates normal erosion process. 1-2 ppm SO_2 nearly doubles drying time with softer finish or more brittle finish with resulting less durable finish.**
- **SO_2 discolors colors.**
- **SO_2 & Ozone increased erosion rate of paints**
- **Polyurethane tensile strength reduced by NO_2 alone and by NO_2 and O_3**

Leather

- With SO_2 exposure leather loses its strength and disintegrates

Ceramics

- Ceramics and glass are impervious to most corrosive gases but some can be damaged by fluorides

Plastics

- Test: PE, PP, PS, PVC, PA, butyl rubber, nylon, polyurethane. All loss strength exposed to SO_2, NO_2, O_3.
- Butyl rubber more susceptible to SO_2 and NO_3 but even more pronounced to O_3
- Nylon suffered chain scission;
- PP cross-linked;

Paper

- Under SO_2, metallic impurities in modern paper accelerates SO_2 and moisture to sulfuric acid. Further, cellulose can be hydrolyzed by acids.

Digital Data Shelf Life Protection

- Digital Data – CD's, CDR, CDW, DVD – are all affected by environmental factors
  - **Ozone** –active oxygen oxidizes the AL layer
  - **Corrosive Gases** – corrode metallic layer
  - **UV Light** – UV light can degrade the protective topcoat layer of the digital disc
  - **ESD** – testing at Lucent has shown that with as little as 2800 volts damage can occur but at 12,700 volts the AL layer will be damaged
  - **Fungal / Mould** growth affecting topcoat
  - **EFFECT –** 20Mb data loss replacement est. $64,400 (US National Security Association)

Digital Storage Test

- EMI Records conducted a 18-month shelf life test on unsealed Intercept (inserts & jewel boxes) to protect CDs/DVDs from data loss, delamination, corrosion (original test planned for only 1 month)
- Results: Intercept proved far superior to standard commercial storage protection

Some Intercept Applications

- **Shelf Life extension** by eliminating ozone & corrosive gas deterioration
- **Indoors/outdoors** depot & forward deployed shipped & stored vehicles, aircraft, ships, equipment, materials
- **OEM shipped** items needing protection AND item **access** (Customs, inspection, maintenance, documentation placement, equipment placement)
- **Reusable** zipper bags and heat sealable bags
- **Retrograde** returns from the field
- **Work-in-progress** protection (OEM, depot, field)
- Anti-corrosive **shelter** construction
- **Anti-Mold / anti-mildew** packaging
- Digital **Data preservation** (CDs, hard drives)
- **Solderability** preservation of electronics

More Intercept Applications

- **Totally envelope** aircraft, vehicle, item or group
- **Partial** cover (w/ perimeter seal)
- **Pallet cover** (sealed at bottom edge)
- **VERTREP** & **UNREP** movement
- **Heat seal bags** from bulk material
- Tri-wall, breakdown boxes, or MILVAN box **liners**
- Intercept **laminations** provide electro-magnetic shielding from radar, stray voltage, future EM and EMP weapons
- **NBC** fallout **protection**
- **Service life extension** during transport and storage w/ Intercept lined carrying cases
- **Re-usability** due to its long, stable useful life and continual cleansing action

Where Can It Be Used?

- Subzero to tropical **temperature** extremes
- 0-100 percent **humidity**.
- Extreme **Ultraviolet** Exposure (w/SCS)
- High **Wind** Exposure (w/SCS)
- To augment **existing packaging**
- On **any** piece of equipment
- Field, Ship, Base, and OEM

When Can It Be Used?

- **Short-term** or **Long-term** (10+ years)
- **Shipping** and/or **Storage** (A, B, C)
- When **environmental** issues are a concern.
- When **training** is limited.
- When shipping **dimensions** are limited.
- When **access** is necessarily.
- When **flexibility** is needed
- When **reusability** is desired

Reasons to Use Intercept

- **Save Manpower**
  - **Reduce** Shelf-Life **Extensions**
  - **Reduce** stock **rotation**
  - **Reduce** product order **oversight**
  - **Reduce MSDS's** required (eliminate VCI use)
  - **Reduce time** required to seal bags / enclosures / boxes

Reasons to Use Intercept

Save Money & Time

- **Extend** product **shelf life**; **improve** product **performance** & **appearance**
- **Increase** buying **efficiency** – allows quantity/size requirement increase
- **Increase** purchase **options** – new products with wider selection
- **Increase** quantity packaging **selection**
- Provides **re-usable** packaging
- **Maintain proper storage** – in-transit, depot, field
- **Reduce Waste** – turn-in material maintained in usable condition
- **Increase** design **flexibility** – allows reduction of other preservatives; increases product purity (contamination) and function
- **Environmental protection**

DOD Directive 5000.1

Signed May 12, 2003

- Applies to all DoD acquisitions
- Acquire quality products that satisfy user needs with measurable improvements to mission capability and operational support
- Integrate advanced technology into producible systems and deployed in the shortest time practicable
- MDAs shall identify the **total costs of ownership**, and total ownership costs

DOD Directive 5000.1

- For new procurements, reprocurements, modifications, upgrades of systems, subsystems, and spares that are procured beyond the initial production contract award.
- Performance-based strategies, contract requirements shall **limit the use of military specifications and standards to Government-unique requirements**
- Trade-off decisions involving cost, useful service, and effectiveness shall consider **corrosion prevention and mitigation**
- Safety considerations shall include includes human/system interfaces, toxic/**hazardous materials** and substances
- PMs shall consider supportability, **life cycle costs**, performance

MIL-STD 3003(AT)

- “**Environmentally preferable materials** shall be used to maximum extent possible…”
- “**Use of new or commercially available products is encouraged**…”
- Where materials are not covered by a specific spec, or std, the manufacturer shall provide **documented testing evidence** (Intercept Technology has been extensively testing!!!)

Intercept Technology Testing
(12 years of data)

- Fortune 500 Companies
- ASTM B-117 (one and three-gases)
- Bell Labs tested ozone permeation
- US Military/NASA testing
- Foreign military testing: Singapore; England, Japan, Israel, Australia
- Testing comparisons against MIL-B-131J foil, VCIs, pink poly, etc.
- National Park Service - proposed

Intercept Technology™ COTS Products Available NOW!

- Bags - Flat and reusable Zipper Closure
- Polyester Corrosion Intercept ® **Bags (Clear)**
- Extrusion coated paper and fabric
- Moisture Barrier Bags - SIF 2000
- Export Bags – replacing foil for export shipments
- Cushion Bags, Pouches and Rolls
- Thermoformed Trays and Totes
- Archival boxes lined with Intercept
- PP Plastic Corrugate - Boxes and Sheet
- Intercept Shrink Film for large equipment
- Intercept Stretch Film
- Clear Intercept Coated PET

Summary

- **Most cost effective** (all factors considered)
- **Safest** for personnel and equipment
- **Most capable** protection
  - Anti-ozone; Anti-corrosive
  - Opaque or translucent
  - ESD protection
  - Passive mold/mildew protection
  - Water vapor proof (SIF)
  - Clean room certified
  - Reusable
  - Most flexible: nearly any packaging form; any size/shape item protection; works with other packaging

Learn more at:

- **www.InterceptShrinkfilm.**
- **www.StaticIntercept.com**
- **www.Omega-Intercept.co**
- **www.LibertyPackaging.co...**
- **www.shrinkwrapping.com/Intercept.html**

Intercept Technology Group

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